NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

THESIS

AN ASSESMENT OF THE PERFORMANCE-BASED MEASUREMENT BATTERY (PBMB), THE NAVY'S PSYCHOMOTOR SUPPLEMENT TO THE AVIATION SELECTION TEST BATTERY (ASTB).

by

Steven D. Ostoin

December 2007

Thesis Advisor: Brent A. Olde
Second Reader: Michael E. McCauley

Approved for public release; distribution is unlimited

REPORT DOCUMENTATION PAGE	*Form Approved OMB No. 0704-0188*

1. AGENCY USE ONLY *(Leave blank)*	**2. REPORT DATE** December 2007	**3. REPORT TYPE AND DATES COVERED** Master's Thesis

4. TITLE AND SUBTITLE An Assessment of the Performance-Based Measurement Battery (PBMB), the Navy's Psychomotor Supplement to the Aviation Selection Test Battery (ASTB).	**5. FUNDING NUMBERS**
6. AUTHOR(S) Steven D. Ostoin	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Postgraduate School Monterey, CA 93943-5000	**8. PERFORMING ORGANIZATION REPORT NUMBER**
9. SPONSORING /MONITORING AGENCY NAME(S) AND ADDRESS(ES) N/A	**10. SPONSORING/MONITORING AGENCY REPORT NUMBER**

11. SUPPLEMENTARY NOTES The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.

12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution is unlimited	**12b. DISTRIBUTION CODE**

13. ABSTRACT (maximum 200 words)

The Aviation Selection Test Battery (ASTB) has been used to screen prospective aviation candidates for the Navy, Marines, and Coast Guard since World War II. The Navy has continuously looked for ways to update and improve its aviation screening procedures and the latest supplement of the Performance-Based Measurement Battery (PBMB) currently under development is just one example. The Naval Operational Medicine Institute (NOMI) is currently investigating how well this test will assist with the difficult process of aviation candidate selection. This study was conducted to assess whether individuals with aviation experience would perform better on the PBMB than those with no aviation experience. Forty individuals participated in this research, 20 had formal aviation training. The results showed that experienced aviators performed significantly better on eye-hand coordination tracking tasks than the group with no aviation experience.

14. SUBJECT TERMS Performance Based Measurement Battery, PBMB, Psychomotor skills, Psychomotor test, ASTB, Aviation Candidate Selection	**15. NUMBER OF PAGES** 67
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	**18. SECURITY CLASSIFICATION OF THIS PAGE**	**19. SECURITY CLASSIFICATION OF ABSTRACT**	**20. LIMITATION OF ABSTRACT**
Unclassified	Unclassified	Unclassified	UU

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. 239-18

THIS PAGE INTENTIONALLY LEFT BLANK

AN ASSESMENT OF THE PERFORMANCE-BASED MEASUREMENT BATTERY (PBMB), THE NAVY'S PSYCHOMOTOR SUPPLEMENT TO THE AVIATION SELECTION TEST BATTERY (ASTB)

Steven D. Ostoin
Commander, United States Navy
B.S., Purdue University, 1990

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN OPERATIONS RESEARCH

from the

NAVAL POSTGRADUATE SCHOOL
December 2007

Author: Steven D. Ostoin

Approved by: Brent A. Olde
Thesis Advisor

Michael E. McCauley
Second Reader

James N. Eagle
Chairman, Department of Operations Research

THIS PAGE INTENTIONALLY LEFT BLANK

ABSTRACT

The Aviation Selection Test Battery (ASTB) has been used to screen prospective aviation candidates for the Navy, Marines, and Coast Guard since World War II. The Navy has continuously looked for ways to update and improve its aviation screening procedures and the latest supplement of the Performance-Based Measurement Battery (PBMB) currently under development is just one example. The Naval Operational Medicine Institute (NOMI) is currently investigating how well this test will assist with the difficult process of aviation candidate selection. This study was conducted to assess whether individuals with aviation experience would perform better on the PBMB than those with no aviation experience. Forty individual participated in this research, 20 had formal aviation training. The results showed that experienced aviators performed significantly better on eye-hand coordination tracking tasks than the group with no aviation experience.

THIS PAGE INTENTIONALLY LEFT BLANK

TABLE OF CONTENTS

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF FIGURES

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF TABLES

THIS PAGE INTENTIONALLY LEFT BLANK

EXECUTIVE SUMMARY

This thesis performed an assessment of the Navy's Performance-Based Measurement Battery (PBMB) under development and intended to supplement the Aviation Selection Test Battery (ASTB). These findings will augment the validation study currently being conducted by the Naval Operational Medicine Institute (NOMI) in Pensacola, Florida.

A total of 40 individuals attending the Naval Postgraduate School volunteered to participate in this study. Of those 40 volunteers, 20 had received formal aviation training as either a pilot or Naval Flight Officer (NFO). All participants were administered the test battery which consisted of three components: a direction orientation test, a dichotic listening test (DLT), and a multi-tracking task. Combinations of these components were then used to make up two multi-tasking tests: the multi-tracking with DLT subtests and the multi-tracking with the emergency procedures (EP) subtests.

Results indicate that those with aviation experience performed better on all multi-tracking tasks. The aviation experience group and the group without aviation experience showed the largest significant difference on the multi-tasking test comprised of the multi-tracking and emergency procedures (F = 12.49, p = .001). Background demographics like the amount of video games played were determined to be immaterial. The aviation experience group and the group without aviation experience did not differ in regard to the performance on the direction orientation test (F = 0.57, p = .48).

Overall, the PBMB was capable of detecting important eye-hand coordinated tracking skills and with further analysis and refinement to the scoring algorithm, this test battery should improve future aviation candidate selection.

ACKNOWLEDGMENTS

I would like to acknowledge those who made this thesis work possible:

To my advisor and second reader, thanks for your support, instruction and supervision.

To my parents, my sincerest thanks for your guidance and encouragement in all that I do.

To my wife and children, I am eternally grateful for your patients, love and understanding.

THIS PAGE INTENTIONALLY LEFT BLANK

I. INTRODUCTION

A. BACKGROUND

Since the armed forces of the United States started using aircraft in combat, there has been a dedicated effort to make certain that the right candidates are selected for a career in military aviation. The United States Navy (USN) quickly recognized that the individuals selected needed to possess the appropriate physical and mental attributes required to become successful aviators. Flying an aircraft has always been considered a dangerous and costly occupation. The costs required to properly train and equip a pilot or flight officer have continued to escalate. It is important that an organization have the ability to accurately select the right individual from a pool of applicants. In 1993, training a single Student Naval Aviator (SNA) in a jet aircraft exceeded $900,000 (Hewes, 1994). Given that this is such an expensive evolution, the USN makes every attempt to minimize the chance of selecting an individual without the proper skill sets into the initial aviation candidate selection process.

This monetary cost drives the Navy, Marine Corps, and Coast Guard services to keep flight school failure rates as low as possible. Improvement efforts resulted in the development of the Aviation Selection Test Battery (ASTB). Since the adoption of the ASTB, it has been consistently used as the criterion for selecting officer aviation program applicants. The ASTB was revised by the Naval Operational

Medicine Institute (NOMI) in cooperation with the Educational Testing Services (ETS) in Princeton, New Jersey, in 1992 (NOMI, 28 Sep 2007).

The United States, particularly NOMI, has continued to make improvements in the ASTB since its initial creation. Not all the proposed modifications have been formally adopted but those that made the cut have proven to improve the selection process. Many of these tests were created during the World War II era and remain, for the most part, unchanged (Griffin, 1996). A prime example is the perceptual-cognitive “paper and pencil” type examinations.

The ASTB has been a successful aptitude test in the candidate selection process. This test battery assesses an applicant’s math skills, the ability to extract meaning from written material, familiarity with mechanical concepts and simple machines, and the ability to perform mental rotations in order to determine the spatial orientation of aircraft in 3-dimensional space. The ASTB also measures an individual’s knowledge of aviation and nautical terminology, familiarity with aircraft components and function, knowledge of basic aerodynamic principles, and the ability to grasp flight rules and regulations. From the entire test battery, four scores are derived from the combinations of the subtests. The predictive validity of the Academic Qualifications Rating (AQR) (used in prediction of SNA academic grades) is $r = 0.45$ ($p < .001$), while the validity of the Pilot Flight Aptitude Rating (PFAR) (used to predict SNA flight grades) is $r = 0.35$ ($p < .001$). The current test battery is viewed

by many experts as adequate in its ability to predict individuals who will succeed during aviation training (NOMI, 28 Sep 2007).

Although the current test battery does have a proven track record, it could benefit from further improvement. One particular area under refinement is psychomotor testing. An appropriate eye-hand coordination test would be beneficial in refining the ability of the ASTB to predict whether or not a Student Naval Aviator (SNA) will succeed during the flight portion of aviation training. According to Damos (1996), the vast majority of current pilot selection batteries are better predictors of training performance rather than operational performance. Others share a similar belief on the present aviation test batteries. Additionally, Damos along with McFarland (1953) believe that data obtained from observational methods do not appropriately reflect some of the more important aspects of a pilot's job which are the cognitive and psychomotor skill sets (Damos, 1996). A task analysis performed by NAVAIR has shown that eye-hand coordination is one of the most important physical skills candidates should possess (Mangos, 2005).

The Federal Aviation Administration (FAA) also believes that psychomotor or physical skills are important traits for aviators. These types of skills are required to conduct many routine tasks when flying an airplane. Besides basic airmanship, some typical activities which involve eye-hand coordination include the ability to fly a precision instrument approach procedure, programming a GPS receiver, or using sophisticated maintenance equipment. As physical

tasks and equipment become more complex, the requirement for integration of cognitive and physical skills increases at a proportional rate (FAA, 1999).

B. PSYCHOMOTOR TESTING

The idea of using eye-hand coordination testing in aviation selection is not a new concept. As early as the 1930’s, tests involving psychomotor skills proved to be reasonably successful. During World War II, the primary psychomotor test used for pilot selection was the Mashburn automatic serial-action complex coordinator. This test involved a timed coordination of stick and rudder movements in response to 40 different visual patterns and proved to be a good predictor of performance (DeHart, 2002). This apparatus did have a down side. It was bulky and special training was required to assemble and collect data. Because logistical requirements made it difficult to transport between testing sites, its use was discontinued by 1951 (Deckart, 1988).

Recent improvements in modern technology have allowed the Navy to directly address some of these limitations. The cost incurred in managing hardware, software, and technical support for such a large quantity of testing sites has become less expensive and more manageable. Additionally, the availability of the personal computer and off-the-shelf hardware such as joysticks, throttles, and rudder pedals has allowed psychomotor testing to become less cumbersome and easier to administer to applicants. Internet connectivity has provided an expanding reach in testing, scoring, and the maintenance of an accurate database on all prospective aviation candidates. These advancements have allowed the

aviation community to expand eye-hand coordination testing options and develop relevant tests to determine which particular tasks can help refine the aviation selection process. These advancements have resulted in approximately 150 Navy testing facilities across the United States and on average 10,000 Navy, Marine, and Coast Guard applicants a year taking the ASTB (Olde and Walker, 2006).

Since these tests have become easier to develop and administer, studies have been conducted as to their relevance. Delaney (1992) evaluated the use of a psychomotor task (PMT) in the aviation selection process. Included with this particular PMT was a dichotic listening task (DLT). The statistical evaluation of the automated DLT and PMT concluded that both skills contributed to the prediction of primary flight-training criteria (Delaney, 1996). The results from this study suggested that assessing concurrent psychomotor tracking and DLT performance may be a particularly effective way of predicting performance in flight training. Large-scale validation studies of the Air Force's computerized psychomotor test have reinforced these findings (Carretta, 1989).

Delaney (1992) determined that psycho-motor based measures could account for an additional 14.8% of unique variance, above what was already being accounting for by the ASTB. Griffin and Koonce (1996) had similar results and concluded that psychomotor based tests could explain 16% more variance than the standard paper and pencil version of the ASTB. These two studies indicate that psychomotor tests can explain approximately 15% more unique variability between aviators who get low flight grades versus those

aviators who get high flight grades. This may be contributed to the fact that a psychomotor test measures eye-hand coordination and tracking skills, skills not currently assessed by the standard cognitive based version of the ASTB (Olde & Walker, 2006).

The Navy’s Performance-Based Measurement Battery (PBMB) is a group of timed, interactive psycho-motor subtests assessing a number of different skills and abilities including multi-tasking, eye-hand coordinated tracking, task prioritization, decision making, and spatial orientation. These skills and abilities have been shown to be particularly important in aviation (FAA, 1999). Detailed directions are displayed on the computer screen prior to the commencement of all seven subtests. The PBMB also provides a practice session for all the subtests except the last one (an emergency procedures test). Also, all subtests had to be completed within the allocated time otherwise the participant would not receive a valid score.

This thesis is intended to assess the performance of the current version of the PBMB, which is still under development and intended for use to supplement the Navy’s ASTB. These findings will augment the validation study being conducted by NOMI in Pensacola, Florida. Specific questions addressed in this thesis include:

Do individuals with aviation experience perform better on the PBMB than those with no flight experience?

Do individuals who play sports, video games, or have other unique demographic background characteristics perform better on the PBMB?

Do participants have any usability issues when taking the PBMB?

This project is in support of the Navy’s effort to develop a psychomotor test that can successfully identify applicants with good eye-hand coordination and multi-tasking abilities prior to being accepted into the aviation training pipeline.

THIS PAGE INTENTIONALLY LEFT BLANK

II. METHODS

The latest version of the PBMB was administered to 40 volunteers. This sample consisted of two subgroups. The first group was comprised of volunteer test subjects with formal aviation experience while the other group had no aviation experience. We hypothesize that the qualified aviators on average, possess more fine tuned psychomotor skills. We expected this group to average a higher score on the psychomotor test than the group with no aviation experience. It was beyond the scope of this study to investigate how the aviation group developed better eye-hand coordination skills. We simply assumed that they possessed those skills and that the battery would accurately assess this difference. We realize that these traits could be a manifestation of inherent natural ability or learned through countless hours of formal aviation training and experience. If humans have eye-hand coordination as an inherent trait, then it is anticipated that some of the participants with no formal flight training would score as well as those individuals with aviation experience, but as a group those with no formal flight training should produce a lower average score. The primary goal of this research is to explore the fidelity of this new selection test battery and investigate whether or not this particular version of the PBMB can correctly identify important characteristics such as eye-hand coordination and spatial orientation ability.

A. SUBJECTS

The PBMB was administered to 40 volunteers attending the Naval Postgraduate School located in Monterey California during a three week period in the Fall of 2007. All but one of the volunteers was serving on active duty and nine individuals were representatives from five different foreign military services.

B. APPARATUS

Advancements in computers and software technology have resulted in a substantial improvement in the way selection tests can be administered. They have also allowed for improvements in the level of sophistication and realism contained in current psychomotor tests. The version used during this research required applicants to use a joystick, throttle, and headphones along with other standard computer hardware to complete the test battery. All the hardware used is available for purchase off the shelf and the APEX delivery system allows for the test to be administered online.

Participants were positioned in a quiet, comfortable environment at standard office desk and chair. The layout used for this experiment is depicted in Figure 1. The computer keyboard was required to complete the demographic section. Once the demographic information was filled out, the mouse and headphones were used to perform the first subtest, direction orientation test (DOT). Upon completion of the DOT, the keyboard was set aside and a joystick and throttle were setup. The joystick, throttle, and headphones were used for the remainder of the examination.

Figure 1. Sitting environment used during the PBMB.

This research project used a Thrustmaster HOTAS Cougar combination throttle and joystick, shown in Figure 2. These controls were designed to replicate those used in an F-16 jet aircraft. For the purpose of standardization, the factory settings on both the joystick and throttle were maintained throughout the experiment, however participants could maneuver them into a comfortable position as long as the throttle was positioned on the left and the joystick was either centered or on the right.

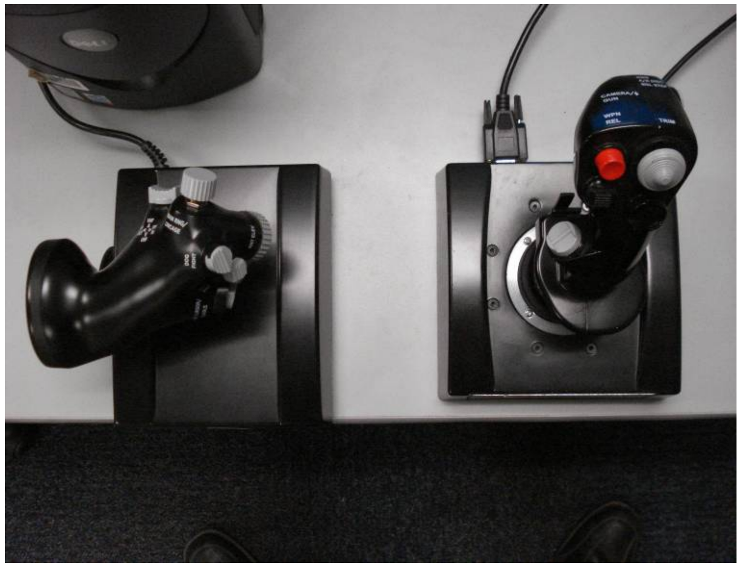

Figure 2. Thrustmaster HOTAS Cougar throttle and joystick combination used for the PBMB.

C. PROCEDURES

The PBMB consisted of the following subtests in the following order:

- Direction Orientation Test (DOT)
- Dichotic Listening Test (DLT)
- Vertical Tracking Test (VTT)
- Airplane Tracking Test (ATT)
- Vertical Tracking Test/Airplane Tracking Test (VTT/ATT)
- VTT/ATT/DLT Multi-task Combination
- VTT/ATT/Emergency Procedures (EP)Scenario

Besides the direction orientation test, the PBMB was designed for each subsequent section to build on each other and provide practice with these novel tasks. The final composite score will be comprised of the DOT, the VTT/ATT/DLT, and the VTT/ATT/EP subtests.

The ASTB PBMB contained a demographic section which was required to be completed before starting the examination but not used in this research. Questions included with the software were name, gender, race, place of birth, date of birth, Social Security Number (SSN), present military status, prior military service, educational level, Grade Point Average (GPA) for highest completed education level, major, experience with flight simulator games or software, any formal flight training, any aviation training - what level and number of hours.

For the research conducted and contained in this thesis, all the participants were asked a different set of background and demographic questions designed specifically to gauge a participant's eye-hand coordination. Additionally, any personal information such as a SSN was substituted with a subject number to assure anonymity. An example of the questionnaire is located in Appendix A.

1. Direction Orientation Test (DOT)

The direction orientation test is the first subtest of the PBMB. It consists of a series of timed exercises that require the subject to determine an aircraft's position relative to a target. This test is used in both the pilot and navigator selection process and assesses the applicant's ability to orient their location from a map view to an outside aerial view of the ground. This particular skill is frequently used in aviation.

For this subtest, the computer screen is divided into two sections. A tracker map is displayed on the left side of the screen which shows the location of the Unmanned

Aerial Vehicle (UAV) and the direction is indicated by an arrow. North is always oriented at the top of the tracker map. The image that is displayed on the right side of the screen is the target. The target is shown as it is viewed through the UAVs camera, depicted below in Figure 3. This camera is mounted beneath an UAV and will always point straight ahead of the UAVs direction of flight.

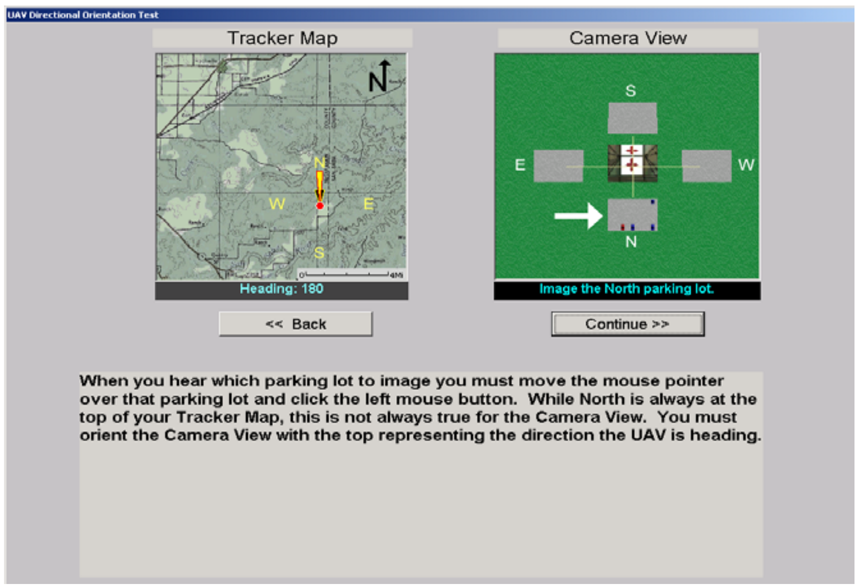

Figure 3. Instruction page. Actual test does not display heading information or an arrow but it does show the same two camera views during the DOT test.

The target used in this subtest consists of a building surrounded by four parking lots. One parking lot is located on each cardinal heading. The participant is asked to select one of the surrounding parking lots as quickly as possible. The specific targeting instructions are received verbally through headphones as well as written below the target map. The participant must move the mouse over the

parking lot to be chosen and then click the left mouse button when the arrow is displayed over that corresponding parking lot. The examinee will receive feedback on their selection. A green circle appears around the selected parking lot when correctly identified. The elapsed time required to make the decision is displayed inside the circle. If an incorrect parking lot is selected, a red circle will appear and the associated elapsed time is displayed inside that circle.

The test was designed to provide a total of eight practice questions before the scored test began. By selecting the “previous” button upon completion of the eighth question, the practice session could be repeated as many times as desired. There are differences between the actual test and the practice test. During the practice session, if an incorrect target is selected, the correct parking lot will be displayed, this is not so during the actual test. The second difference is that after a practice question is answered, the participant must select the “continue” button to advance to the next question, but in the actual test the program advances automatically. The participants are told that their score for the direction orientation task will be calculated using a combination of speed and accuracy of the selected answers.

2. Dichotic Listening Task (DLT)

Pilots and flight officers often listen to multiple radio frequencies at the same time during a flight and it is imperative that they are able to focus on a particular callsign or other important radio transmissions.

During the DLT portion of the PBMB, the participant hears a series of numbers and letters presented to each ear through a pair of headphones, as displayed in Figure 4. The participant will be verbally asked to monitor a “target” ear for even or odd numbers. When an even number is heard in the “target” ear, the examinee is required to press the trigger of the joystick located in their right hand. When an odd number is presented in the “target” ear, the individual is required to press the thumb button of the throttle located in their left hand.

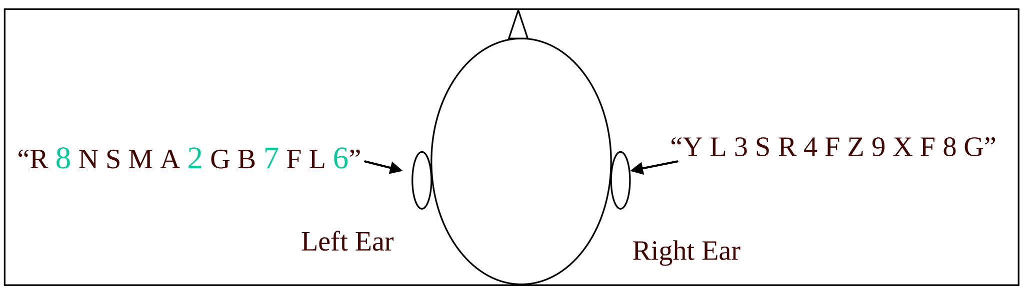

Figure 4. Example of how the DLT test is presented to the subject.

The DLT test is one minute forty seconds in length and scoring is determined by how quickly and accurately the participant responds to each number presented in the “target” ear. It is scored as incorrect if an individual responds to any number being presented to the non-target ear.

3. Vertical Tracking Test (VTT)

The vertical tracking test (VTT) takes one minute to complete and measures an applicant’s ability to track a moving target on a vertical axis. For this subtest, a yellow airplane and a red crosshair are displayed on the

left side of the computer screen. The yellow airplane moves up and down on the screen at increasingly faster speeds. The participant can only control the red crosshair. The object of the test is to keep the airplane inside the red crosshair for as long as possible.

In order to move the crosshair up and down the screen, the participant uses the throttle controls located to their left. When the throttle is moved up, the crosshair will move up on the screen and conversely, moving the throttle down causes the crosshair to move down. If the participant is successful in targeting the airplane, the crosshair will turn green and when the targeting lock is lost, it returns to red.

Three scores are recorded for this task. The first is a total number of correct responses. A correct response is recorded when the pixel distance between the crosshair and aircraft is within a programmed range at a predetermined time check during the task. The second score recorded is an error average distance. This distance is the average distance observed between the center point of the crosshair and the center point of the aircraft over the duration of the subtest. The third score is for the total number of redirects recorded during the task. A redirect is recorded when the subject maintains the crosshair on top of the aircraft for brief amount of time causing the aircraft to change course.

During the VTT, as the participant correctly targets the airplane, it starts moving faster thus progressively increasing the level of difficulty. There are three speeds with which the airplane can move and thus three levels of

difficulty. The VTT was designed to measure how many airplane redirects the participant can induce.

4. Airplane Tracking Test (ATT)

The fourth subtest in the PBMB is the airplane tracking test. This test takes one minute to complete and measures an individual's ability to track a moving target in two dimensions. An airplane and red targeting crosshairs are displayed on the screen. The basis for this examination is for the participant to imagine that they are is attempting to target the airplane shown on the screen. The individual attempts to keep the crosshair centered on the airplane as it moves around the screen. The crosshairs will turn green when the airplane is successfully targeted.

The examinee has no control over the speed or direction of the target. The test subject manipulates the crosshairs by moving the joystick located on their right. When the joystick is moved to the right the crosshairs move right. Conversely, when the participant moves the joystick to the left, the targeting crosshairs move to the left. When the joystick is pushed forward the crosshairs move up and when the joystick is pulled back the crosshairs move down.

The scores recorded for the ATT are similar to the three described in the VTT section. As the participant correctly targets the airplane, it starts moving faster thus progressively increasing the level of difficulty. The ATT was also designed to measure how many airplane redirects the participant can induce.

5. Airplane Tracking Test and Vertical Tracking Test (ATT/VTT)

The ATT/VTT takes two minutes to complete and is the first PBMB subtest that combines two tasks. Both of the tasks required in this test have been previously performed individually. During this section, the subject is assessed on their ability to perform these tasks simultaneously.

The examinee is required to use the joystick to target the airplane on the right side of the computer screen which is moving in two dimensions and operate the throttle control to target the airplane moving along the vertical axis on the left side of the screen, see Figure 5.

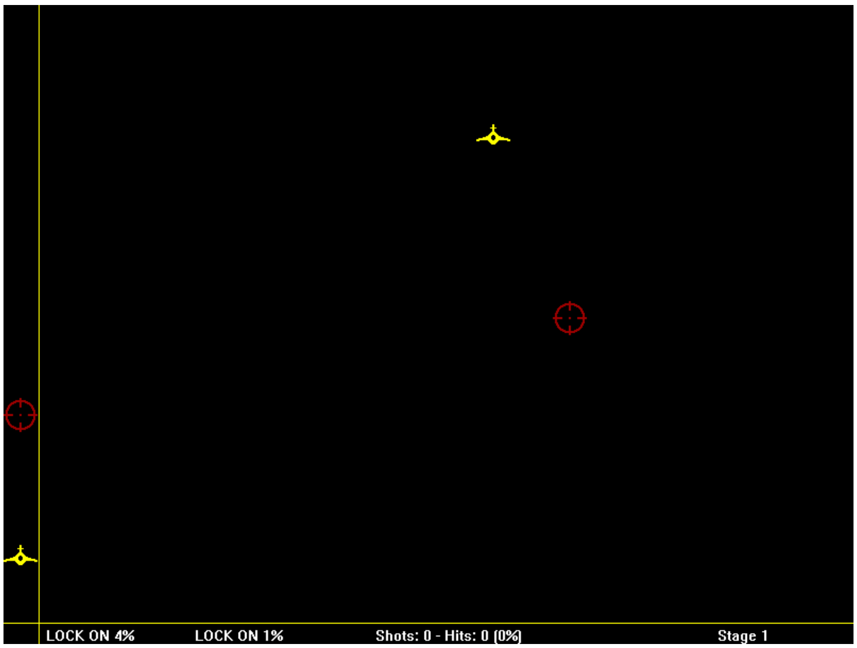

Figure 5. Display used during the ATT/VTT. The aircraft and crosshair shown on the left are for the VTT subset.

The test subject must attend to each task equally during the ATT/VTT because the scoring incorporates how well both airplanes are accurately targeted.

6. VTT/ATT/DLT Multi-task Combination

This multi-task combination test takes three minutes to complete and simulates the high mental workload of some aviation tasks. This test is a mixture of three tasks previously performed. The VTT, ATT, and DLT are all administered during this subtest. The purpose of the multi-task combination test is to assess the subject’s eye-hand coordination while performing the dichotic listening test.

The joystick and throttle operate in the same manner as the VTT/ATT subtest while the dichotic listening task is also performed.

The participant must attend to all three tasks equally. Scoring for the multi-task combination subtest tracks the accuracy of targeting both airplanes, the number of redirects, and the accuracy and speed of the responses to the DLT.

7. VTT/ATT/EP Scenario

The emergency scenario test is intended to replicate the difficult task of dealing with problems while maintaining flight (a task pilots need to be able to perform). While flying an aircraft, emergencies are an ever-present risk. Making inaccurate decisions and untimely responses can be very unforgiving. It is also important that the pilot continues to fly the airplane while dealing with an emergency scenario.

This two minute test taps an individual’s eye-hand coordination plus memory capacity. The emergency scenario test is the final subtest in the PMBM. It utilizes the vertical tracking test and the airplane tracking task while the participant responds to an emergency audio and visual warning. This warning will identify one of three emergency scenarios that are given during the subtest.

The participant must carefully read the detailed instructions provided and memorize the associated responses for each emergency scenario. The applicant will be required to respond to all three emergency scenarios over the course of this subtest. An example of one emergency scenario is a verbal warning such as “Fire, Fire, Fire” followed by the illumination of a fire light. The test subject is then required to respond to the fire emergency using the responses described in the instructions. Fuel and power gauges are adjusted to the appropriate settings. The gauge displays are at the bottom of the screen, see Figure 6. Each emergency contains three actions which can be accomplished by using the throttle located to the left. Two knobs and a button are required to manipulate the appropriate gauges and set them to the correct position for the specific emergency displayed. If an incorrect response or no response is given, the screen will turn red. The applicant is then notified visually that the aircraft systems are operating under duress. If no response is given within the predetermined time, the screen will reset in preparation for the next emergency.

Figure 6. The VTT/ATT/EP as viewed by the subject. Notice the fuel and power gauges added to the bottom right of the screen.

The participant must continue to perform the VTT and the ATT tasks while dealing with the emergency scenario. All three tasks are considered in the final score for this subtest.

III. RESULTS

Of the 40 volunteers, four were female and 36 male, the ages of the subjects ranged from 27 to 43 years old and the median and mean ages were both 33 years.

For the purpose of this study, an individual with flight experience was defined as those participants who received any formal pilot or flight officer training, 20 met this general criterion. This group was comprised of two Naval Flight Officers (NFO) and 18 pilots qualified to fly jets, propeller aircraft or helicopters. The flight experience group also contained one participant with only a private pilot's license (75 hours of flight time), a participant who started but did not complete flight school (200 hours flight time), and one participant that transitioned from a NFO to a pilot. The mean flight time was 1423.75 hours with the minimum number of hours being 75 and 3000 being the maximum. One participant did have flight time as an observer but this qualification did not meet this study's definition of flight experience and therefore they were not included in the flight experience group.

Only two of the participants with aviation experience held a current instrument, instructor or Naval Air Training and Operating Procedures Standardization (NATOPS) qualification at the time of the experiment. The mean time since the last flight was 29 months. The longest time observed was 120 months and the shortest was seven months since their last flight.

Participants were asked how often they played video games and if any of those games were flight simulators.

Fifteen volunteers reported playing video games on a monthly basis and only two indicated they occasionally played flight simulator games. The mean time spent playing video games per month was 5.35 hours with the highest being 60 hours.

All exploratory analysis conducted in this thesis was accomplished using JMP 7 and SPSS personal computer software packages. Unless otherwise noted all results are quoted at the two-tailed 0.05 significance level.

A. SPATIAL ORIENTATION SKILLS

1. Direction Orientation Test (DOT)

A total of 48 questions were asked in the DOT subtest and each participant received two scores. One score was for the total number of correct responses and a second score for the total response time for all correct and incorrect answers.

The mean score of correct responses for the aviation experience group was 39.95 with a standard deviation of 5.09 while the no experience group had a mean of 38.15 and a standard deviation of 6.52. These two means were not statistically significant ($F = 0.95$, $p = .34$).

The mean total response time observed for the group with aviation experience was two minutes twenty three seconds with a standard deviation of one minute thirteen seconds. The group with no experience took slightly longer with a mean time of two minutes thirty seconds and a standard deviation of one minute nineteen seconds, these means were not statistically significant ($F = 0.04$, $p = .84$)

A composite score was created to address the speed and accuracy trade-off of the DOT. The total number correct and total response time for each individual score were standardized and combined (weighted equally). The difference between the mean composite scores of the two groups (0.12 for those with aviation experience and -0.12 for those without) was not statistically significant (F = 0.57, p = .46).

B. LISTENING SKILLS

1. Dichotic Listening Test (DLT)

A total of 16 questions were asked during the one minute forty second DLT portion of the psychomotor test. Those with aviation experience had a mean number of correct responses of 11.9 and a standard deviation of 4.52 while those with no aviation experience had a mean number of correct responses of 10.15 and a standard deviation of 4.34 (see Table 1). The means for the number of correct responses in the DLT were not statistically significant (F = 1.56, p = .22).

The mean total response time for correct responses observed for the group with aviation experience was 0:16.11 seconds with a standard deviation of 0:06.12 seconds. The group with no experience had a mean response time of 0:15.94 seconds and a standard deviation of 0:07.83 seconds. An average time for a correct response was calculated by dividing the total correct time by the total number of correct responses. The number correct and average time were then standardized and weighted equally to calculate a composite score. The difference between the mean composite

scores of the two groups (0.19 for those with aviation experience and -0.19 for those without) was not statistically significant (F = 3.178, p = .083).

DLT Subtest						
	Number Correct		Adjusted Number Correct		Total Response Time for Correct Responses	
	Mean	STD DEV	Mean	STD DEV	Mean	STD DEV
EXPERIENCE	11.9	4.52	20.83	7.906	00:16.1	00:06.1
NO EXPERIENCE	10.15	4.34	17.76	7.602	00:15.9	00:07.8

Table 1. Summary of both adjusted, unadjusted response times for the DLT subtest.

C. EYE-HAND COORDINATED TRACKING SKILLS

1. VTT, ATT, and VTT/ATT Tests

For the purpose of this study, we defined eye-hand coordinated tracking skills as the one and two dimensional tracking accomplished with the joystick and throttle. The subtests containing tracking skills varied in duration. The shortest time was one minute for the VTT and ATT with the longest being three minutes for the VTT/ATT/DLT.

For each of the VTT and ATT tracking skills, a total of three scores were recorded. The first score was the number of correct responses, the second was the average distance error between the crosshairs and the airplane, and the third score was the total number of times the participant caused the aircraft to redirect because of capture. It should be noted that the lower the error average distance the closer the crosshairs remained to the aircraft during the test.

The correlations between the different tracking tasks and the different tracking measures were all highly correlated (see Table 2). The first three rows in each matrix are the number correct, error average, and number of redirects for the VTT. Rows three through six are the number correct, error average, and number of redirects for the ATT test. Row seven is a sum of the number correct for the VTT and ATT test. Row eight is an average of the error average for the VTT and ATT test and row nine is the sum of the total number of redirects for the VTT and ATT test in each subtest. Since the number correct, error average, and number of redirects are so highly correlated, only the number of redirects will be reported from this point on (number of redirects was selected because the PBMB was designed to use it as its primary measure of tracking skill).

	VTT Correct	VTT Error Avg	VTT Redirect	ATT Correct	ATT Error Avg	ATT Redirect	Total Correct	Total Error Avg	Total Redirect
VTT/ATT/DLT Subtest									
VTT Correct	1.00								
VTT Error Avg	-0.93	1.00							
VTT Redirect	0.99	-0.92	1.00						
ATT Correct	0.71	-0.62	0.70	1.00					
ATT Error Avg	-0.60	0.61	**-0.59**	-0.89	1.00				
ATT Redirect	0.70	-0.62	0.69	0.99	-0.90	1.00			
Total correct	0.93	-0.85	0.92	0.92	-0.80	0.91	1.00		
Total Error Avg	-0.84	0.88	-0.83	-0.85	0.91	-0.86	-0.92	1.00	
Total Redirect	0.91	-0.83	0.91	0.93	-0.82	0.93	1.00	-0.92	1.00
VTT/ATT/EP Subtest									
	VTT Correct	VTT Error Avg	VTT Redirect	ATT Correct	ATT Error Avg	ATT Redirect	Total Correct	Total Error Avg	Total Redirect
VTT Correct	1.00								
VTT Error Avg	-0.94	1.00							
VTT Redirect	0.99	-0.95	1.00						
ATT Correct	0.68	-0.71	**0.67**	1.00					
ATT Error Avg	-0.70	0.69	-0.67	-0.85	1.00				
ATT Redirect	0.68	-0.71	0.68	0.99	-0.87	1.00			
Total Correct	0.94	-0.92	0.94	0.88	-0.83	0.88	1.00		
Total Error Avg	-0.86	0.89	-0.86	-0.86	0.95	-0.87	-0.94	1.00	
Total Redirect	0.92	-0.92	0.92	0.90	-0.84	0.91	0.99	-0.94	1.00

Table 2. Correlation matrix of scores for the VTT/ATT/DLT and VTT/ATT/EP.

2. Vertical Tracking Test (VTT)

The experienced group induced redirects at a significantly higher rate than those without aviation experience, 17.9 and 15.5, respectively, $F(1,39) = 4.59$, $p = .04$ (see Table 3).

3. Airplane Tracking Test (ATT)

Again, the experienced group induced redirects at a significantly higher rate than those without aviation experience, 9.95 and 6.05, respectively, $F(1,39) = 7.92$, $p = .008$ (see Table 3).

4. Vertical Tracking Test/Airplane Tracking Test (VTT/ATT)

The total number of redirects for the VTT/ATT subtest was calculated by adding the VTT number of redirects with the ATT number of redirects. The experienced group induced redirects at a significantly higher rate than those without aviation experience, 26.55 and 18.5, respectively, $F(1,39) = 9.72$, $p = .004$ (see Table 3).

5. VTT/ATT/DLT Multi-task Combination

In this subtest, the VTT/ATT scores were combined as in the previous section. The number of correct responses from the DLT was also recorded.

The experienced group induced redirects during the VTT/ATT/DLT subtest at a significantly higher rate than those without aviation experience, 37.35 and 23.15, respectively, $F(1,39) = 10.66$, $p = .002$. However, the DLT mean number correct was not statistically different between the group with aviation experience and those without aviation experience, 21.1 correct and 20.65 correct respectively, $F(1,39) = 0.06$, $p = .81$ (see Table 3). When a composition score for speed and accuracy was calculated using the average time for a correct response (same method described in the DLT section), the DLT mean composite scores between the two groups were not significant ($F = 0.11$, $p = .75$)

To determine the impact of the DLT on tracking skills, the mean number of redirects was adjusted for the one minute time difference between the VTT/ATT subtest and the VTT/ATT/DLT subtest so these two tests could be directly

compared (see Table 3). Both groups experienced a drop in the mean number of redirects when the additional DLT task was added. The adjusted mean number of redirects for the VTT/ATT was compared to the mean number of redirects for the VTT/ATT/DLT for each group. Assuming unequal variance, the means for the group with aviation experience were 39.83 and 37.35 (Prob. > |t| 0.59) and the means for the group without aviation experience were 27.75 and 23.15 (Prob. > |t| 0.25). Although these means are not statistically different, they do trend in the expected direction.

The adjusted DLT mean number of correct responses (see Table 1) was compared to the mean number of correct responses for the DLT section of the VTT/ATT/DLT for each group. Assuming unequal variance, the means for the group with aviation experience were 20.83 and 21.1 (Prob. > |t| 0.89) and the means for the group without aviation experience were 17.76 and 20.65 (Prob. > |t| 0.22). These means are also not statistically different, however it is interesting to note that both groups performed better on the DLT the second time they took it (VTT/ATT/DLT) even though they were also performing a dual-tracking task.

6. VTT/ATT/EP Scenario

The emergency scenario subtest was two minutes long and this section was treated similar to the VTT/ATT/DLT. The VTT/ATT number of redirects for the VTT/ATT/EP subtest was combined in a single score. The number of correct emergency responses was tallied with a maximum score achievable being three. The elapsed time to respond to each emergency was also recorded.

The experienced group induced redirects during the VTT/ATT/EP subtest at a significantly higher rate than those without aviation experience, 21.05 and 11.9, respectively, $F(1,39) = 12.49$, $p = .001$ (see Table 3). However, the mean number of correct EP’s was 2.2 for the group with experience and 1.85 without aviation experience, these means were not statistically different ($F = 1.12$, $p = .30$). When a composite score taking into account the speed and accuracy of responses during the emergency scenario was calculated (using the same method described in the DLT section), the composite mean scores (0.40 for the group with experience and -0.40 for those without experience) between the two groups were not statistically significant ($F = 2.05$, $p = .16$).

Since both the VTT/ATT and VTT/ATT/EP subtests were two minutes long, no adjustment to the mean number of redirects was necessary to determine the impact of tracking while performing the EP task (see Table 3). Both groups experienced a drop in the mean number of redirects. Assuming unequal variance, the means for the number of redirects of the aviation experience group were 39.83 and 31.58 (Prob. > |t| 0.049) and the means for the group without aviation experience were 27.75 and 17.85 (Prob. > |t| 0.011). This mean difference is statistically different and trended in the expected direction for both groups.

VTT Subtest				
	Number Redirects		Adjusted Number Redirects	
	Mean	STD DEV	Mean	STD DEV
EXPERIENCE	17.9	3.06	53.7	9.18
NO EXPERIENCE	15.5	3.97	46.5	11.9

ATT Subtest				
	Number Redirects		Adjusted Number Redirects	
	Mean	STD DEV	Mean	STD DEV
EXPERIENCE	9.95	4.37	14.93	6.56
NO EXPERIENCE	6.05	4.39	9.6	7.11

ATT/VTT Subtest				
	Number Redirects		Adjusted Number Redirects	
	Mean	STD DEV	Mean	STD DEV
EXPERIENCE	26.55	8.16	39.83	12.24
NO EXPERIENCE	18.5	8.17	27.75	12.26

ATT/VTT/DLT Subtest								
	Number Redirects		Adjusted Number Redirects		# DLT Correct		DLT Average Time	
	Mean	STD DEV	Mean	STD DEV	Mean	STD DEV	Mean	STD DEV
EXPERIENCE	37.35	16.26	37.35	16.26	21.1	4.54	1.34	0.49
NO EXPERIENCE	23.15	10.67	23.15	10.67	20.65	7.01	1.53	0.61

ATT/VTT/EP Subtest								
	Number Redirects		Adjusted Number Redirects		# EP Correct		EP Average Time	
	Mean	STD DEV	Mean	STD DEV	Mean	STD DEV	Mean	STD DEV
EXPERIENCE	21.05	8.95	31.58	13.42	2.2	0.77	28.4	4.5
NO EXPERIENCE	11.9	7.34	17.85	11.02	1.85	1.27	23.9	12.8

Table 3. Summary of both the unadjusted and adjusted scores for the number of redirects, DLT and EP for the tracking skill subtests.

D. PARTICIPANT DEMOGRAPHICS

Prior to taking the PBMB, participants were asked a series of questions about their perceived eye-hand coordination skills and multitasking abilities. These responses along with the participants' age, gender, aviation experience, amount of video games played, ability to juggle, and ability to dribble a basket ball were analyzed using a

stepwise regression to predict the total number of redirects for the VTT/ATT/EP subtest. Only aviation experience was significant (p = .001). When the same predictors were used to model the number of redirects for the VTT/ATT/DLT subtest, aviation experience (p = .004) and gender (p = .047) were statistically significant predictors. Note, there were only four females in the study and only one had flight experience – this small sample size and unequal cells preclude any predictions based on gender.

THIS PAGE INTENTIONALLY LEFT BLANK

IV. DISCUSSION

Certain subsets of the psychomotor test did support our hypothesis that individuals having flight experience would on average, score higher than those without flight experience.

The most significant results were the mean scores for the eye-hand coordinated tracking tasks. These skills included tracking two airplanes with a throttle and joystick. While we focused on the total number of redirects, either the total number correct responses or the average error distance would have detected the difference in tracking ability between the experienced and non-experienced groups. It has been claimed that eye-hand coordination and tracking skills are important in the field of aviation (Mangos, 2005) and these findings suggest that our selected group of aviator not only had these skills but that the PBMB was able to detect them.

The VTT, ATT, VTT/ATT, VTT/ATT/DLT, and the VTT/ATT/EP sections all produced significant results when comparing the mean number of redirects between the two groups.

The aviation experience group and the group without aviation experience showed the largest significant difference when performing the VTT/ATT/EP (F = 12.49, p = .001). When the adjusted mean number of redirects for VTT/ATT/ subtask were compared to the adjusted mean number of redirects for the VTT/ATT/EP subtask, both groups had a significant decrease in mean scores. This drop in performance was expected because participants were required

to manipulate thumb wheels located on the throttle control during the emergency scenario which diverted attention away from aircraft tracking.

The VTT/ATT/DLT subtest (although not as robust as the VTT/ATT/EP) resulted in a significant difference between the aviators and non-aviators (F = 10.66, p = .002) and was consistent with the findings of Delaney (1992). The difference between the adjusted mean redirects for the VTT/ATT subtest and the mean redirects for the VTT/ATT/DLT subtest showed a decline in performance. Again, this trend was expected due to participants performing another test.

When the adjusted means for the one minute DLT were compared to the DLT portion of the VTT/ATT/DLT subtask, we anticipated that the mean of the average time per correct response for both groups would be higher when the participant's attention was divided among tasks. However, the results showed that both groups mean average time for a correct response decreased. We observed a marginal improvement in the experienced group's performance from a mean of 1.34 to 1.30 seconds and a more substantial improvement for the group with no experience from 1.53 to 1.26 seconds. Although the observed decrease for the two groups was not statistically different, this improvement was unexpected. The most logical explanation for this improvement can be attributed to the novelty of the DLT task causing participants trouble. However, by the time they took the VTT/ATT/DLT section, they may have figured out the procedure and thus their scores improved. This explanation

is even more likely given the participants comments about misunderstanding during the practice portion of the DLT subtest (see the Observations and Recommendations section below).

The DOT did not distinguish between the experienced aviators and the non-experienced group. Since the Navy currently uses a paper and pencil style spatial abilities test in the ASTB which is different from the DOT spatial ability test, they may have to continue relying on that test. The instructions for the DOT test state that the scoring will be determined by the speed and accuracy of a response. Two scores were provided in the data output for this section. One score was a total accumulated time for correct and incorrect responses and the other reported the total number of correct responses. Finding the ideal weighting of these scores in a composite score is beyond the scope of this paper, however we did look at a composite score based on an equally weighted standardize version of the number correct and total response time and found no significant difference between the mean scores for the two groups. The PBMB DOT test was unable to detect a difference in spatial abilities between those with flight experience and those without. Using a more sophisticated weighting scheme may prove more fruitful.

The DLT was another subtest of the PBMB that did not distinguish between the group with aviation experience and the group with no aviation experience. When the mean number correct responses for the DLT was examined, there was no difference between groups. Although the composite score of speed and accuracy did not differ between groups there was

an increase in the F statistic, which was $F = 1.56$ for the mean number correct and $F = 3.18$ for the composite score. The composite score was based on an equally weighted standardize version of the number correct and total time for correct responses. A more sophisticated model of weighting the number correct and total time for correct responses might prove a more robust measure.

It is apparent that those with aviation experience did perform better than those without on the eye-hand tracking skills contained in the psychomotor test. Either of the last two subtests can adequately measure this difference. The DOT subtest did not support our hypothesis, but it appears that dichotic listening may have affected performance during the VTT/ATT/DLT subtest. These two sections may benefit from improvements in data collection, and scoring, and further evaluation of how the final scoring model is produced.

A. OBSERVATIONS AND RECOMMENDATIONS

The directions included before each subtest were found to have sufficient detail. One interesting observation to note pertained to the emergency procedure section. Participants were told to adjust fuel and power levels to either high, low, or neutral depending on the emergency they were presented. However, the gauges were displayed with a red stripe located at the top, green in the middle, and yellow at the bottom, as shown in Figure 6. Although one would normally assume that the top of gauge is a high setting, it had a red indication which may be interpreted as

being low. This subtle difference in directions has the potential to cause some confusion and should be clarified in future test versions.

All practice secessions preceding each subtest could only be performed once except for the direction orientation test. A few of the volunteers were observed repeating the DOT practice session multiple times. This was made possible by selecting the “previous” button upon completion of the eighth practice question. It is unknown whether this extra practice had any influence on the results for the DOT section. The directions should clearly state that participants can repeat the practice section of the DOT or the possibility for repeated practice should be eliminated.

The practice session for the DLT is different than the full DLT test. The 30 second practice session does not switch “target” ears while the actual test does require the participant to shift attention from one ear to the other ear. This inconsistency may have caused some confusion. An individual may not have been expecting a switch in “target” ears on the DLT, but by the end of the test they usually understood the task. This initial shock of switching ears may explain why both groups increase their DLT score later during the VTT/ATT/DLT subtest. Consideration should be given to changing the DLT practice session to include a switch in “target” ears. Furthermore, increasing the length of the actual DLT may ensure sufficient time for learning this novel task.

Participants were given an opportunity to provide feedback on the psychomotor test when the questionnaire was completed. One issue mentioned was that the factory

sensitivity settings on the joystick and throttle were awkward. The throttle had to be moved forward or backward approximately 2/3 of the way to get the crosshairs to begin to move. Also, full right or left movement of the joystick was difficult to achieve without the control unintentionally moving on the table top. Some refinement to the sensitivity setting may be desirable.

Another comment from the majority of the volunteers was the overall difficulty of the test. Of the 40 participants, 38 of them felt that the test was challenging while 24 found it to be extremely challenging. Only two volunteers considered it to be about the right level of difficulty.

V. RECOMMENDATIONS FOR FURTHER RESEARCH

The scope of this study was limited and we only touched the surface of the required analysis needed prior to fielding the Navy’s new psychomotor test for aviator selection. There exists a multitude of opportunities for further research and subtle refinements in the current version of the PBMB.

The first area that should be researched further involves the development and analysis of a model to correctly weight response time with correct responses for both DLT and DOT tests. In this study we elected to equally weight these scores which may not be ideal. Exploring a better weighting scheme should be addressed.

We elected to only look at subjects who had already completed some type of formal flight training. Valuable insight was gained into the tests ability to recognize eye-hand coordination and tracking skills but it is still unknown whether or not this was a learned skill or an inherent ability. Furthermore, the aviator’s adage of aviate, navigate, and communicate may have played a role their disparate scores in the multi-tracking task and emergency scenario subtests.

None of our test subjects were under the age of 27 or currently selected for aviation and awaiting formal flight training. Further research should involve testing this target population. These individuals should be administered the psychomotor test prior to having any aviation experience. They should be tracked throughout their formal flight training and upon completion or discontinuation from

flight school. Their flight school performance could be used to design an appropriate weighted model for the PBMB. Results from a study of this nature should provide further insight into the PBMBs predictive capability and eventually allow for a standard measure to be established for acceptance into flight school.

APPENDIX

Questionnaire

Section 1

1. Participant Number: _______________

2. Age: _________

3. Sex:
   a. Male
   b. Female

4. On a scale of 1 to 5 with 5 being the highest, how would you rate your overall hand eye coordination?
   5 - Excellent
   4 - Above average
   3 - Average
   2 - Below Average
   1 - Poor

5. Do you have any aviation experience?
   a. Yes
   b. No

If you answered no to question 5 skip to question 13.

6. Is your flight experience as a:
   a. Pilot
   b. Flight officer
   c. Flight engineer
   d. Crewmember

7. Is your aviation time
   a. Military
   b. Civilian
   c. Both

8. What type of airframe (circle all that apply)?
   a. Fixed wing – Jet
   b. Fixed wing – propeller
   c. Helicopter
   d. Other

9. Approximately how many total hours would you say you have (rounding is fine)?

____

____

10. What is the highest qualification you have held? (Instructor, mission commander, test pilot etc): ____

____

11. Are any of your qualifications still current?
    a. Yes – all
    b. Yes - some
    b. No

12. How long has it been since your last flight (in months)?

____

____

13. On average, how much time per month do you play video games (in hours)?

____

____

14. Are any of the video games flight simulators?
    a. Yes
    b. No

15. On a scale of 1 to 5 with 5 being the highest, circle how athletic you think you are
    5 - Should have turned pro
    4 - Above average
    3 - Average
    2 - Below average
    1 - Always the last kid picked

16. Are you currently playing any sport (recreational or organized)?
    a. Yes
    b. No

17. Have you ever played any organized sport?
    a. Yes
    b. No

18. What sport and what position (example: baseball, short stop)?

---

19. On a scale of 1 to 5 with 5 being the highest, circle how well would you think you are at multitasking?

    5 - Excellent
    4 - Above average
    3 - Average
    2 - Below Average
    1 - Poor

20. The game is on the line and it all comes down to one final play. If the play is made, your team wins, if not, you lose. Do you want to be the one who:

    a. Is in position to make the play. You have the utmost confidence in your ability.
    b. Is in the play but the entire thing does not hinge on your actions.
    c. Is out there to back up the individual up who makes the game winning play.
    d. Is not currently in the game but has a front row seat.
    e. Not applicable - wouldn't be playing in a sporting event

21. Can you juggle?

    a. Yes
    b. No

22. How well would you say you can dribble a basketball?

    5 - Excellent
    4 - Above average
    3 - Average
    2 - Below Average
    1 - Poor

Section 2

1. How well do you think you did on the test?
   5 - Excellent
   4 - Above average
   3 - Average
   2 - Below Average
   1 - Poor

2. How would you rate the difficulty of the exam?
   5 - Extremely challenging
   4 - Challenging
   3 - Just about right
   2 - Walk in the park
   1 - I could do it with my eyes closed

3. What did you like about the exam?

____

____

4. What did you not like about the exam?

____

____

Would you say this is an accurate assessment of your hand-eye coordination (explain why or why not)?

____

____

LIST OF REFERENCES

Carretta, T. R. (1989). Cross Validation of Experimental USAF Pilot Training Performance Models. Military Psychology, 2(4), 257-264.

Damos, D. L. (1996). Pilot Selection Batteries: Shortcomings and Perspectives. The International Journal of Aviation Psychology, 6(2), 199-209.

Deckert, W. R. (1988). A Model That Uses Psychomotor Testing to Predict Naval Aviator Primary Flight Grades. Master's Thesis, Naval Postgraduate School Monterey California.

DeHart, R. L., Davis, J. R. (2002). Fundamentals of Aerospace Medicine. Lippincott Williams and Wilkins.

Delaney, H.D. (1992). Dichotic Listening and Psychomotor Task Performance as Predictors of Naval Primary Flight-Training Criteria. The International Journal of Aviation Psychology, 2(2), 107-120.

Department of Transportation, Federal Aviation Administration (1999). Aviation Instructor's Handbook (pp.1-10). Retrieved October 20, 2007 from http://www.faa.gov/library/manuals/aviation/media/FAA-H-8083-9.pdf.

Griffin, G. R. (1987). Development and evaluation of an automated series of single and multiple dichotic listening and psychomotor tasks. (Tech Rep No NAMRL 1336), Pensacola FL, Naval Aerospace Medical Research Laboratory.

Griffin, G. R., Koonce, J.M., (1996). Review of Psychomotor Skills in Pilot Selection Research of the U.S. Military Services. The International Journal of Aviation Psychology, 6(2), 125-147.

Hewes, M. C. (1993). Flight training costs. Naval Education and Training Program Management Support Activity, Resource Management and Analysis Office, Course Costing Branch.

Mangos, P. M. et al. (2005), Interim Technical Report: Analysis of Work of Naval Aviation Training Pipelines, NAVAIR Orlando, Training Systems Division.

McFarland, R. A., (1953). Human Factors in Air Transportation, New York, McGraw-Hill.

Naval Operational Medicine Institute (n.d.). ASTB Information and Sample Questions. Retrieved on September 28, 2007, from http://www.nomi.med.navy.mil/Nami/astb/astbwebsitewriteup.htm.

Olde, B. A., & Walker, P. B. (2006). The Automatic Pilot Examination (APEX): The Navy’s Online Testing System for Selecting Naval Aviators. In *Proceedings of the Human Factors and Ergonomics Society 50th Annual Meeting* (pp. 2269-2273). Santa Monica, CA: Human Factors and Ergonomics Society.

INITIAL DISTRIBUTION LIST

1. Defense Technical Information Center
   Ft. Belvoir, Virginia

2. Dudley Knox Library
   Naval Postgraduate School
   Monterey, California

3. LT Brent A. Olde, MSC, USN, Ph.D.
   Naval Postgraduate School
   Monterey, California

4. LT Peter B. Walker, MSC, USN, Ph.D.
   Naval Operational Medicine Institute
   Pensacola, Florida